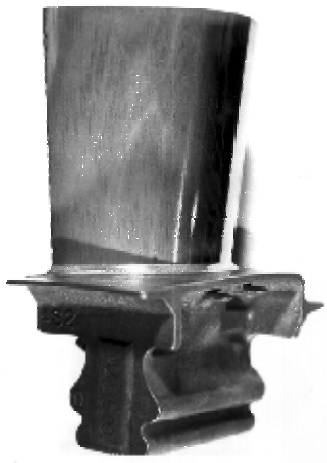
KNOWLEDGE - INTEGRATED SOLUTION HEAT TREATMENT PROCESS FOR TURBINE AIRFOILS (A0712)



Heat-treated René N4 turbine airfoil
used in F-404 engine for F/A-18 aircraft.

PROBLEM / OBJECTIVE

A heat treatment consisting of solutioning and subsequent aging is required to develop optimum mechanical properties in directionally solidified (DS) and single crystal (SX) superalloy turbine airfoils. In the past, investment casting foundries have used trial-and-error methods to determine the solution temperature and time and employed conservative stepwise heat-up procedures to prevent incipient melting. As a result, the solution heat treatment time is longer than necessary, thus increasing the cost as well as delaying delivery. The objective of this project was to develop an efficient, knowledge-integrated technology to optimize the solution heat treatment of superalloy turbine airfoils.

APPROACH / BUSINESS STRATEGY

NCEMT has developed the solution heat treatment technology models, and has transferred the results to industry. Technical consultation on the solution heat treatment processes of turbine airfoils has been provided by the F-404 and F-414 engines manufacturer, GE Aircraft Engines (GEAE). PCC Airfoils and Howmet, qualified turbine airfoils vendors for F-404 and F-414 engines, have conducted turbine airfoil casting and heat treatment production trials and implemented the solution heat treatment technology into their production operations.

ACCOMPLISHMENTS /PAYOFF

Process Improvement:

Optimized processes, which halved the total solution heat treatment processing times, have been tailored for alloys René N4 and René N5 used for the turbine airfoils in F-404 and F-414 engines. A tailored solution heat treatment process for the alloy René N6, used in F-110 engines for the Air Force F-16 aircraft as well as the CF-6 engine for the Boeing 744 and GE-90 for the Boeing 777, is nearing completion.

Industry Acceptance:

In addition to implementing this technology into their production of F-404/-414 airfoils, PCC Airfoils has contracted Concurrent Technologies Corporation (CTC) to tailor a solution heat treatment process for alloy René 142 using the technology developed in this NCEMT project used in commercial applications such as GE's GE-90 engine for the Boeing 777. Howmet is in the process of contracting CTC to tailor solution heat treatment processes for alloys CMSX-4 and CMSX-10 used in the Tomahawk Cruise Missile.

This successful development of tailored solution heat treatment processes for turbine airfoils has lead to a

proposed ManTech process to optimize the aging processes for turbine airfoils. This new effort is supported by both the F404/414 program offices and industry.

Implementation:

Two new efficient solution heat treatment processes for alloys René N4 and René N5 have been approved by the F-404 and F-414 engine manufacturer, GEAE, and implemented into investment casting foundry production procedures at both PCC Airfoils and Howmet. Benefiting weapon systems include the F/A-18E/F, JSF, Tomahawk, and Air Force's F-22.

Technology Transfer:

An end-of-project demonstration was conducted in September 1996. Application of this technology to a broad variety of military and commercial engine requirements is possible.

Expected Cost Reduction:

Estimated cost savings for turbine airfoils of F-404 and F-414 engines is $2.5M over 7 years (FY96-FY03). Savings for the F-119 should be similar.

TIMELINE / MILESTONES

Start Date: September 1993
End Date: March 1997

This project included the following major tasks:

1. Modeling diffusion-controlled solution processes;
2. Finite difference thermal analysis of solution heat treatment processes;
3. Experimental verification of effect of solution heat treatment procedures on material microstructures;
4. Integration of results into a solution heat treatment optimization methodology; and
5. Transfer of technology to industry.

FUNDING

Navy ManTech Funding:

Estimated Navy ManTech Total Cost: $500K

In-Kind Support:

GE Aircraft Engines (technical consultation): $20K
PCC Airfoils (process qualification): $20K
Howmet (process qualification): $40K
Air Force Materials Lab (technical consultation): $10K

Leverage:

Production experience of GEAE, PCC Airfoils, and Howmet $1M

Related Effort:

PCC Airfoils and GEAE IR&D projects (implementation of the technology developed in this project): $100K

PARTICIPANTS

Development and Implementation Partners

NCEMT
GE Aircraft Engines
PCC Airfoils, Inc.
Howmet Corporation

POINTS OF CONTACT

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